



Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at <http://about.jstor.org/participate-jstor/individuals/early-journal-content>.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

THE PHARYNGO-ŒSOPHAGEAL LUNG OF DESMOGNATHUS.

HARRIS H. WILDER.

SINCE the discovery of lungless salamanders in 1894, numerous investigators have endeavored to ascertain the method of respiration in these forms. Camerano (1894), after a series of physiological experiments upon *Spelerpes fuscus*, came to the conclusion that integumental respiration was no better developed than in other Amphibia, and that the respiration must be mainly bucco-pharyngeal. Directly along this line Maurer (1897) showed that in lungless forms the pharyngeal capillaries pass beyond the corium and actually invade the epidermis, a condition unique among vertebrates. Hopkins (1896) supplied an interesting point of negative evidence, that in lungless salamanders the pulmonary vein is entirely wanting, and that correspondingly the left atrium is reduced to a rudiment. This view was slightly modified by Bruner (1900), who showed that what Hopkins had taken for the *septum atriorum* was really a valve and that a proper septum did not exist, hence the single atrium of lungless forms is probably due to a confluence of the original two.

A careful study of the blood vessels of both lunged and lungless salamanders was conducted by Bethge (1897), with the result that he located in the latter (*Spelerpes fuscus*) a pharyngeal plexus of capillaries, the vessels of which seemed swollen at irregular intervals. Miss Woldt (1897) found a pulmonary artery in *Plethodon*, supplying both œsophagus and skin.

Thus far, however, the investigation seems to have centered about the organs of circulation, and, consequently, a curious set of facts along a different line has been entirely overlooked. Although these have been met with and described by various investigators, no conclusions have been drawn from them.

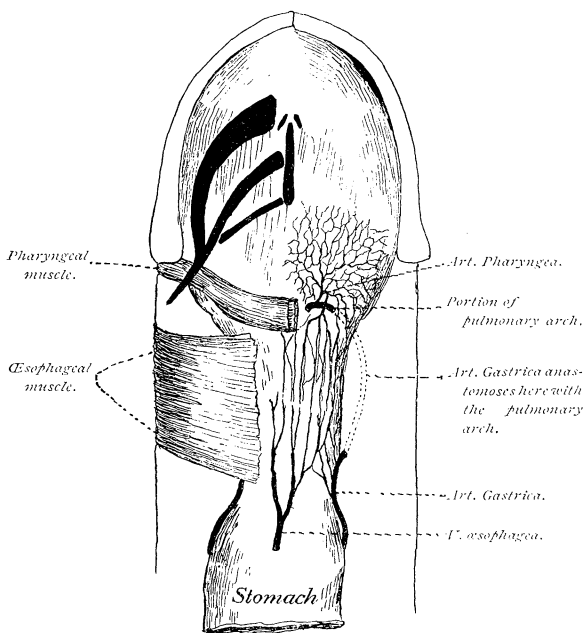
The first of these is the obvious fact, to which my attention was first directed by Dr. H. S. Pratt, that lungless forms breathe in the same way as do other salamanders; that is, they indulge in rhythmic respiratory movements during which the throat fluctuates in and out with considerable rapidity. A second closely related fact is that recorded by Bruner (1896), that, in common with salamanders with lungs, the several species of lungless forms investigated possess a muscular apparatus for opening and closing the anterior nares. Although in lunged forms this apparatus is directly connected with the respiratory act, Bruner, influenced by the general opinion that lungless forms could not really breathe, explained the presence of this apparatus in such genera as *Desmognathus* and *Spelerpes* as solely a protection against water. The third fact, which has remained entirely unexplained until now, is the presence in lungless salamanders of well-developed respiratory muscles identical with those possessed by other Urodeles and inserted into the walls of the pharynx and œsophagus (Wilder, 1896).

The meaning of these incongruous and apparently unrelated facts has at last been made clear through the careful investigations of one of my assistants, Miss Anne Ide Barrows, whose preliminary report on the subject has just appeared in the *Anatomischer Anzeiger* (Bd. XVIII, Nos. 18, 19). Miss Barrows has just concluded a long and exhaustive study of the entire circulatory system of *Desmognathus fusca* and has succeeded in demonstrating that *not only the pharynx*, as shown by Bethge in *Spelerpes*, *but also the entire œsophagus, is supplied with a dense capillary plexus, the vascular area of which is of sufficient extent to transform the entire pharyngo-œsophageal region into a functional lung of at least as great respiratory power as that of the paired lungs of normal salamanders*. The plexus is formed mainly by four arteries, two external maxillaries on the dorsal, and two pharyngeal on the ventral side. Posteriorly a few branches of the gastric artery contribute to the formation of the plexus.

It is worthy of note that a large part of the plexus is formed by arteries from the fourth or respiratory arch, and that much

of the aerated blood is not returned directly to the heart but enters the hepatic portal system through a pair of œsophageal veins.

The demonstration of this respiratory organ puts the necessary meaning into the three facts enumerated above, for since there is a functional lung there must be respiratory movements performed by respiratory muscles, and thus the true function, both of the small muscles about the anterior



Ventral aspect of pharynx and œsophagus of *Desmognathus fusca*, showing the plexus of blood vessels. The background of this figure was drawn by the author, based upon one published in 1894. The blood vessels were added by Miss Barrows.

nares and the large internal set, becomes evident. Concerning these latter, the respiratory movements induced by them are of two kinds: an act of inspiration which expands the pharyngo-œsophageal region and an act of expiration which contracts it again. The muscles employed in inspiration are evidently those which arise from various dorsal and lateral points and become inserted along the sides of the pharynx and œsophagus, called by me the dorso-laryngeus, scapulo-pharyngeus, and

oesophageal muscle. These by their contraction draw apart the walls of the alimentary canal in this region, and the external air rushes in through the nostrils to fill the vacuum thus formed. In my previous paper, not having the present point of view, I said little about the muscles used in expiration, but it is now obvious that the well-developed muscular layer which surrounds the pharynx in some of the species, and which I have figured in Fig. 2 of the article referred to under the name of pharyngeal muscular sheet, must have that function. It is also probable that in some species the *digastricus pharyngis* becomes a powerful expiratory muscle.

Summarizing the results thus far obtained, we may state the following: *Desmognathus fusca* breathes mainly by means of a definitely localized portion of the anterior part of the alimentary canal, which may be known as the *pharyngo-oesophageal lung*. *The walls of this organ are richly supplied with blood from a capillary plexus which is irregularly reticular in its pharyngeal portion, and in its oesophageal portion consists mainly of very numerous longitudinal vessels which run parallel with the mucous folds. Rhythmic inspiratory and expiratory movements of this organ are caused by two sets of muscles, the one dilating and the other contracting the lumen.*

These motions are accompanied and assisted by respiratory movements of the floor of the mouth, as in other salamanders. The mouth is normally closed during respiration, and the nostrils are used for the passage of air. The anterior nares are equipped with a regulating apparatus, as in other salamanders, and for the same purpose.

Although the above summary rests upon recent investigation upon a single species, it is probable that a similar organ exists, with some slight modifications, in the other lungless salamanders. The bibliography referred to here merely by the author's name is given in full in Bruner's latest article on the subject in the *Journal of Morphology*, February, 1900, to which the reader is referred.